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Response to the First Five-Year Review Report for the Test Reactor Area, Operable Unit 2-13, at the Idaho National Engineering and Environmental Laboratory

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Prepared for the
U.S. Department of Energy
DOE Idaho Operations Office

ABSTRACT

The *First Five-Year Review Report for the Test Reactor Area, Operable Unit 2-13, at the Idaho National Engineering and Environmental Laboratory* concluded that the selected remedies implemented under the *Final Record of Decision Test Reactor Area Operable Unit 2-13* were protective of human health and the environment. The First Five-Year Review Report also identified several issues that warranted further investigation to ensure the continued effectiveness of the selected remedies. These issues included the recurrence of diesel in Well PW-13, increasing Co-60 in Well PW-12, increasing Sr-90 in several perched-water wells, continued usage of the Test Reactor Area facility beyond the 2007 closure assumed in the pre-Record of Decision model, and fluctuations in perched-water chemistry. Investigative activities included fieldwork, modeling, and conceptual model research. The activities concluded that the identified issues do not affect the selected remedies. Other activities, including a Track 2 investigation of a release site that is potentially related to the Sr-90 activities, are ongoing and will be completed in the next fiscal year. Findings from the Track 2 investigation will be detailed in a Track 2 summary report. Additionally, the advancement of weed control and establishment of better native vegetative cover is currently being pursued through the updating of planning and methods described in PLN-611, "Sitewide Noxious Weed Management." The revision of this plan is expected to be completed during the next fiscal year and is not discussed in this report.

SUMMARY

The *First Five-Year Review Report for the Test Reactor Area, Operable Unit 2-13, at the Idaho National Engineering and Environmental Laboratory* (DOE-ID 2003) concluded that the selected remedies implemented under the *Final Record of Decision Test Reactor Area Operable Unit 2-13* (DOE-ID 1997a) were protective of human health and the environment. The First Five-Year Review Report also identified several issues that warranted further investigation in order to ensure the continued effectiveness of the selected remedies. Those issues include the recurrence of diesel in Well PW-13, increasing Co-60 activities in Well PW-12, increasing Sr-90 activities in several perched-water wells, extended use of the Test Reactor Area (TRA) facility beyond the 2007 closure date that was assumed for the pre-Record of Decision (ROD) calculations, large fluctuations in perched-water chemistry, and the establishment and maintenance of desirable vegetation on native soil covers for the Sewage Leach Pond and Chemical Waste Pond. This report details the investigation and activities completed for each of the identified issues with the exception of the ongoing vegetative cover issue. The establishment and maintenance of desirable vegetation are addressed elsewhere. Additionally, a Track 2 investigation regarding a release site is ongoing and the summary report is scheduled to be completed during the next fiscal year.

The sporadic recurrence of diesel fuel at Well PW-13 was investigated through historical research and sampling. Two new wells also were drilled and installed to monitor the perched-water body proximal to PW-13. The investigation indicates that the diesel recurrence is due to subsurface cycling of diesel fuel from a historical leak. There is no evidence of a new diesel fuel leak. The diesel probably entered the subsurface from a historical leak in a fuel transfer line, identified in a Track 2 investigation of PW-13 and a Track 1 investigation of the fuel transfer line. The cycling of the diesel into and out of PW-13 is likely to occur for a period of years and passive collection of the diesel is recommended on a trial basis for 1 year.

A geochemical investigation was conducted to explore the observed large fluctuations in the perched-water chemistry. The investigation served several purposes, including the fingerprinting of the various zones in the perched-water body, identification of source water, characterization of subsurface geochemical conditions, and definition of hydrogen and oxygen isotope ratios of the perched water. Sampling of perched-water wells and selected aquifer wells was conducted in March 2004 to provide a completed data set for this effort. The investigation indicates that the perched-water body consists of several different water types. The major sources include the Cold Waste Ponds, the Chemical Waste Pond, and water similar to the Snake River Plain Aquifer (SRPA). The similarity between the SRPA water and water collected from perched-water wells at TRA seems to indicate that raw SRPA water might be leaking from utility pipes. Although the recharge sources to the perched water do not contain contaminants, the infiltrating water does provide a mechanism for contaminant migration.

Increasing Co-60 activities were identified in samples collected from Well PW-12. The March 2003 activity exceeded the maximum contaminant level (MCL) of 200 pCi/L. Subsequent samples collected from the well indicated decreasing activities and were below the MCL. This investigation indicated two potential causes for the unexpected increase in Co-60 activities; both potential causes are transient. The fluctuating activities could be the result of changing subsurface conditions. Transient changes in water chemistry could cause more residual Co-60 to be mobilized and transported in flow toward the well, thereby causing the higher activities observed in the well. When the water chemistry returns to baseline conditions, Co-60 levels will decrease. Alternatively, historically documented and investigated release sites near Well PW-12 have left some residual Co-60 contamination in the subsurface. Changes in the location and rate of water infiltrating through residual contamination could cause fluctuations observed in PW-12. The increase and subsequent decrease in Co-60 in PW-12 have

occurred at least once in the past and it seems that spikes in Co-60 in PW-12 may continue to occur until the residual contamination has decayed away or the perched-water body dissipates.

The spike in Co-60 measured in PW-12 is consistent with the conceptual model of the site and does not warrant further investigation. Continued monitoring is recommended. Six mechanisms were identified in the first five-year review as potentially controlling the fluctuations in contaminant concentrations in certain perched-water wells. The mechanisms include (1) adsorption/desorption occurring with changing perched-water levels, (2) changing flow pathways in response to remediation and fluctuations in discharge to the Cold Waste Pond (or between alternating cells), (3) seasonal variations of natural infiltration at a local scale, (4) variations in recharge from unidentified manmade sources, (5) lateral flux from the Big Lost River, or (6) new leaks of contamination from unidentified sources. Of the six mechanisms considered, it was concluded that the variable discharge to the Cold Waste Pond likely was the primary cause for the observed fluctuations. The variations in discharge to the ponds and the changes in discharge location as the pond use is rotated likely cause the perched-water system to change significantly. The investigation also indicated that new sources for the contaminants in question are highly unlikely.

A review of modeling efforts performed in support of the ROD also was conducted. Simulations were run using the original modeling code and assumptions in confirmation of the original predictions. The model was then run using updated assumptions, most importantly the extended operational life of TRA, which includes extended period of discharge to the Cold Waste Ponds. The updated assumptions also were used in a second set of simulations that employed a state-of-the-art, commercially available modeling code. The input from both modeling codes indicated that the remedy would remain protective of human health and the environment, even with the extended operational life of the TRA. New modeling, assuming an extended operational life of 2024, predicted that all contaminants of concern were projected to be well below their MCLs by 2115, the date used for the future-use risk assessment.

The investigations into the issues raised during the completion of the first five-year review did not reveal evidence or information that would negate the remedies selected in the ROD (DOE-ID 1997a). The selected remedies remain protective of human health and the environment. Although the investigations did not negate the remedy, they did provide recommendations for future actions.

Recommendations are made suggesting individuals supporting Comprehensive Environmental Response, Compensation, and Liability Act activities at TRA take the following actions: (1) stay abreast of ongoing research into the TRA facility during closure for issues that might affect groundwater quality, such as Voluntary Consent Order operations; (2) maintain a current knowledge of improvements in modeling software that may allow for more accurate modeling of the TRA subsurface; (3) conduct periodic reviews of new developments in hydrogeologic and geochemical research that may be relative to the TRA subsurface; and (4) perform installation and monthly maintenance of petroleum traps in three perched-water wells. The findings also support the recommended monitoring defined in the *Groundwater Monitoring Plan for the Test Reactor Area Operable Unit 2-13* (DOE-ID 2004a) in accordance with the ROD (DOE-ID 1997a).

CONTENTS

FIGURES

TABLES

ACRONYMS

amsl	above median sea level
bls	below land surface
BTEX	benzene, toluene, ethylbenzene, and xylene
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	*Code of Federal Regulations*
COC	contaminant of concern
CWP	Cold Waste Pond
DEQ	[Idaho] Department of Environmental Quality
DOE	U.S. Department of Energy
DOE-ID	U.S. Department of Energy Idaho Operations Office
DR	dual rotary
EPA	U.S. Environmental Protection Agency
ETR	Engineering Test Reactor
GMWL	global metoric water line
ICP	Idaho Completion Project
ID	identification
INEEL	Idaho National Engineering and Environmental Laboratory
INTEC	Idaho Nuclear Technology and Engineering Center
INWIMIS	INEEL Nonradiological Waste Management Information System
MCL	maximum contaminant level
MTR	Materials Test Reactor
ND	not detected
NM	not measured
OU	operable unit
PZNPC	point of zero net proton charge

RCT	radiological control technician
ROD	Record of Decision
SRPA	Snake River Plain Aquifer
TRA	Test Reactor Area
USC	*United States Code*
USGS	United States Geological Survey
VCO	Voluntary Consent Order
WWP	Warm Waste Pond

Response to the First Five-Year Review Report for the Test Reactor Area, Operable Unit 2-13, at the Idaho National Engineering and Environmental Laboratory

1. INTRODUCTION

The purpose of the *First Five-Year Review Report for the Test Reactor Area, Operable Unit 2-13, at the Idaho National Engineering and Environmental Laboratory* (DOE-ID 2003) was to evaluate and determine whether the remedies prescribed by the *Final Record of Decision Test Reactor Area Operable Unit 2-13* (DOE-ID 1997a) are expected to remain protective of human health and the environment. The selected remedy was found to be protective in the short term; however, the First Five-Year Review Report (DOE-ID 2003) identified several issues requiring more in-depth evaluation to ensure protectiveness over the long term. These issues do not currently negate the remedy's protectiveness of the aquifer, but they must be evaluated prior to the second five-year review to ensure continued protection of human health and safety and the environment.

The remedy for the Test Reactor Area (TRA),[a] Operable Unit (OU) 2-13 at the Idaho National Engineering and Environmental Laboratory (INEEL)[b] included consolidating and capping contaminated sediments, removing contaminated materials, maintaining institutional controls, and monitoring the decrease of contamination in groundwater caused by radioactive decay, dispersion, and natural attenuation. The selected remedies and institutional controls were implemented in accordance with the OU 2-13 Record of Decision (ROD) (DOE-ID 1997a), as modified by the *Explanation of Significant Differences to the Record of Decision for Test Reactor Area Operable Unit 2-13* (DOE-ID 2000). Institutional controls and monitoring are implemented through the *Groundwater Monitoring Plan for the Test Reactor Area Operable Unit 2-13* (DOE-ID 2004a) and the *INEEL Sitewide Institutional Controls Plan* (DOE-ID 2004b) and reported through monitoring reports and annual institutional controls reports.

The purpose of this report is to (1) document the response actions taken to the issues identified in the first TRA five-year review, (2) present the findings from the response actions, and (3) satisfy requirements for follow-on activities driven by the first TRA five-year review. The second five-year review for TRA is required by September 2008—5 years from the date of the U.S. Environmental Protection Agency (EPA) review (EPA 2003). This requirement will be met by including TRA in the next INEEL Sitewide five-year review that is proposed for 2005.

The U.S. Department of Energy (DOE) is preparing this report pursuant to Section 121 of the "Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA/Superfund)" (42 USC § 9601 et seq.) and 40 *Code of Federal Regulations* (CFR) 300, "National Oil and Hazardous Substances Pollution Contingency Plan."

1.1 Summary of Issues Identified in the First Five-Year Review

After reviewing the First Five-Year Review Report (DOE-ID 2003), the EPA, Region 10, determined that the remedy for OU 2-13 currently protects human health and the environment because institutional controls are in place and functioning and because trends for contaminants of concern (COCs) in the aquifer are either below maximum contaminants levels (MCLs) or are projected to be below MCLs

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a. The Test Reactor Area is now called the Reactor Technology Complex.

b. The Idaho National Engineering and Environmental Laboratory is now called the Idaho National Laboratory.

by 2012, based upon data trends presented in the first five-year review, 4 years earlier than the date predicted by pre-ROD modeling. However, in order for the remedy to be protective in the long term, the EPA specified that several tasks would need to be completed before the next five-year review (EPA 2003). These actions are listed in Table 1 along with the response taken by the INEEL to address each issue.

The following sections of this report begin with a summary of the physical and hydrogeologic setting of TRA (Section 2). It is followed by Section 3 that describes the activities undertaken to define and understand the continued presence (since 1990) of floating diesel fuel on perched water near Well PW-13 (Section 3). Section 4 presents the geochemical investigation of perched and aquifer water at TRA performed to characterize various sources of water for the perched-water body. During the five-year review, Co-60 was observed in Well PW-12 to have increased to levels exceeding the MCL (the levels have since dropped below the MCL). The historical Co-60 levels in PW-12 are presented in Section 5 along with a detailed discussion of potential sources. Section 6 considers mechanisms that might cause concentrations of Sr-90 and Co-60 to rise and fall over periods of months to years, contrary to the anticipated continuous decline expected from radioactive decay and attenuation. Section 7 describes the numerical modeling activities undertaken to update the assumption in the ROD (DOE-ID 1997a) that the TRA would be decommissioned in 2007 and, thus, terminate the sources of the perched water (primarily the Cold Waste Pond [CWP]). A summary of the investigation is provided in Section 8, and recommendations are provided in Section 9.

2. PHYSICAL AND HYDROGEOLOGIC SETTING

The TRA was established in the early 1950s for the purpose of studying radiation effects on materials, fuels, and equipment. A general map of TRA and the surrounding vicinity with monitoring wells and waste disposal ponds is shown in Figure 1. For reference, the area within the double security fence at TRA is about 1,700 × 1,900 ft (approximately 70 acres). The TRA is located on an alluvial plain consisting of surficial sediment with thickness ranging from 30 to 75 ft. A series of basalt flows interbedded with sedimentary deposits of eolian and fluvial origin underlie the surficial sediments. The sedimentary interbeds vary in both thickness and lateral extent. The basalt contacts, often rubbly and highly vesicular, are typically very permeable, water-bearing intervals in both the perched-water zones and the underlying Snake River Plain Aquifer (SRPA). The basalt/sediment interfaces and the unfractured, massive basalts in the centers of flows have much lower permeabilities and act as aquitards and perching layers. The combination of complicated geology, a semiarid climate (~8.7 in. annual precipitation), and infiltration from anthropogenic sources leads to a thick vadose zone (~450 ft thick) that contains perched-water bodies of varying size.

This section provides background regarding the hydrologic setting at TRA. Section 2.1 describes the physiographic setting. Lithology and stratigraphy are provided in Section 2.2. The main perched-water bodies are described in Section 2.3 and the underlying SRPA is described in Section 2.4.

2.1 Physiographic Setting

The TRA is situated within the INEEL at a location approximately 8 mi east of the Lost River Range promontory on the Snake River Plain of southeastern Idaho (Figure 2). The land surface at TRA is gently sloped to the southwest and is relatively flat with elevations ranging from 4,945 ft on top of a rubble pile in the CWP to 4,908 ft at the bottom of the Chemical Waste Pond. The TRA is located on thick deposits of alluvial gravels associated with the relatively flat floodplain of the Big Lost River. The

Table 1. Summary of five-year review issues and Idaho National Engineering and Environmental Laboratory responses.

Issue from Five-Year Review	Summary of INEEL Response	Reference
Perform a field characterization effort to identify the extent and source of diesel in the PW-13 perched-water well.	Investigated potential diesel sources, installed two new perched-water wells near Well PW-13, sampled new wells and selected existing wells for dissolved constituents of diesel fuel, evaluated natural attenuation of diesel, and performed analysis of natural mechanisms for "cycling" diesel in the subsurface.	Section 3 of this report
Perform a geochemical investigation to fingerprint various water sources at TRA to correlate sources of water to perched-water wells.	Performed additional sampling of perched and aquifer wells, examined the distribution of contaminants in the perched water to determine sources of contaminants, characterized water sources based on major ion chemistry and oxygen and hydrogen isotope data to determine water sources, evaluated flow paths using oxygen and hydrogen isotope data and major ion chemistry data, and combined information on contaminant sources and water sources to characterize perched-water bodies.	Section 4 of this report
Perform a systematic analysis to identify the source of increasing Sr-90 and Co-60 in the perched water.	Investigated potential sources for Co-60 near Well PW-12, evaluated historical contaminant trends in perched-water wells, assessed natural mechanisms that might create nonidealized behavior, and examined new research suggesting that nonideal behavior may be a characteristic common to fractured rock vadose zones.	Sections 5 and 6 of this report
Evaluate the impacts of continued TRA operations on the perched-water system and the assumptions used in the OU 2-13 ROD (DOE-ID 1997a).	Developed a water budget for water use at TRA, updated the pre-ROD model with new operational scenario, and developed a new vadose flow and transport model using a commercially available, modern numerical simulator.	Section 7 of this report
Revise the Groundwater Monitoring Plan (DOE-ID 2004a) based on monitoring data.	Modified the Groundwater Monitoring Plan (DOE-ID 2004a) and reduced the number of analytes to include only chromium, tritium, Sr-90, and Co-60 and to include one round of sampling for Tc-99 and I-129.	Groundwater Monitoring Plan (DOE-ID 2004a)
Address improved establishment of desirable native vegetation and control of intrusive species on the covers at the site.	Actions are planned to control intrusive weed species to enhance the covers' structural integrity by providing greater resistance to erosion and animal intrusion.	Draft update in May 2004 of PLN-611, "Sitewide Noxious Weed Management," December 2002. Revision to be PLN-1313, "Weed Control and Revegetation Status Report for Fiscal Years 2002 through 2004 and Schedule for Fiscal Years 2005 and 2006 (Draft)."

DOE-ID = U.S. Department of Energy Idaho Operations Office
INEEL = Idaho National Engineering and Environmental Laboratory
OU = operable unit
PLN = plan
ROD = Record of Decision
TRA = Test Reactor Area

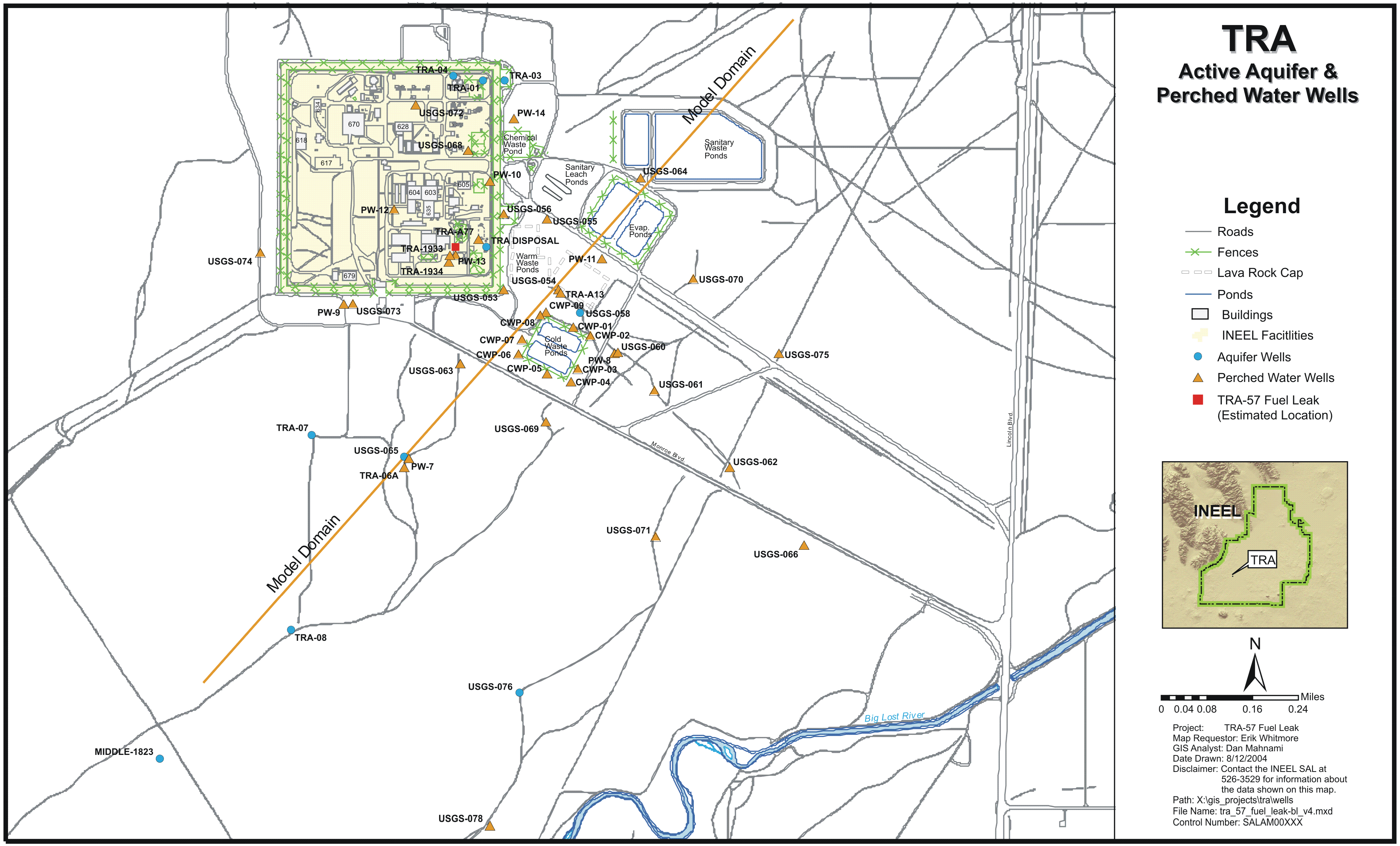

Figure 1. Map of the Test Reactor Area.

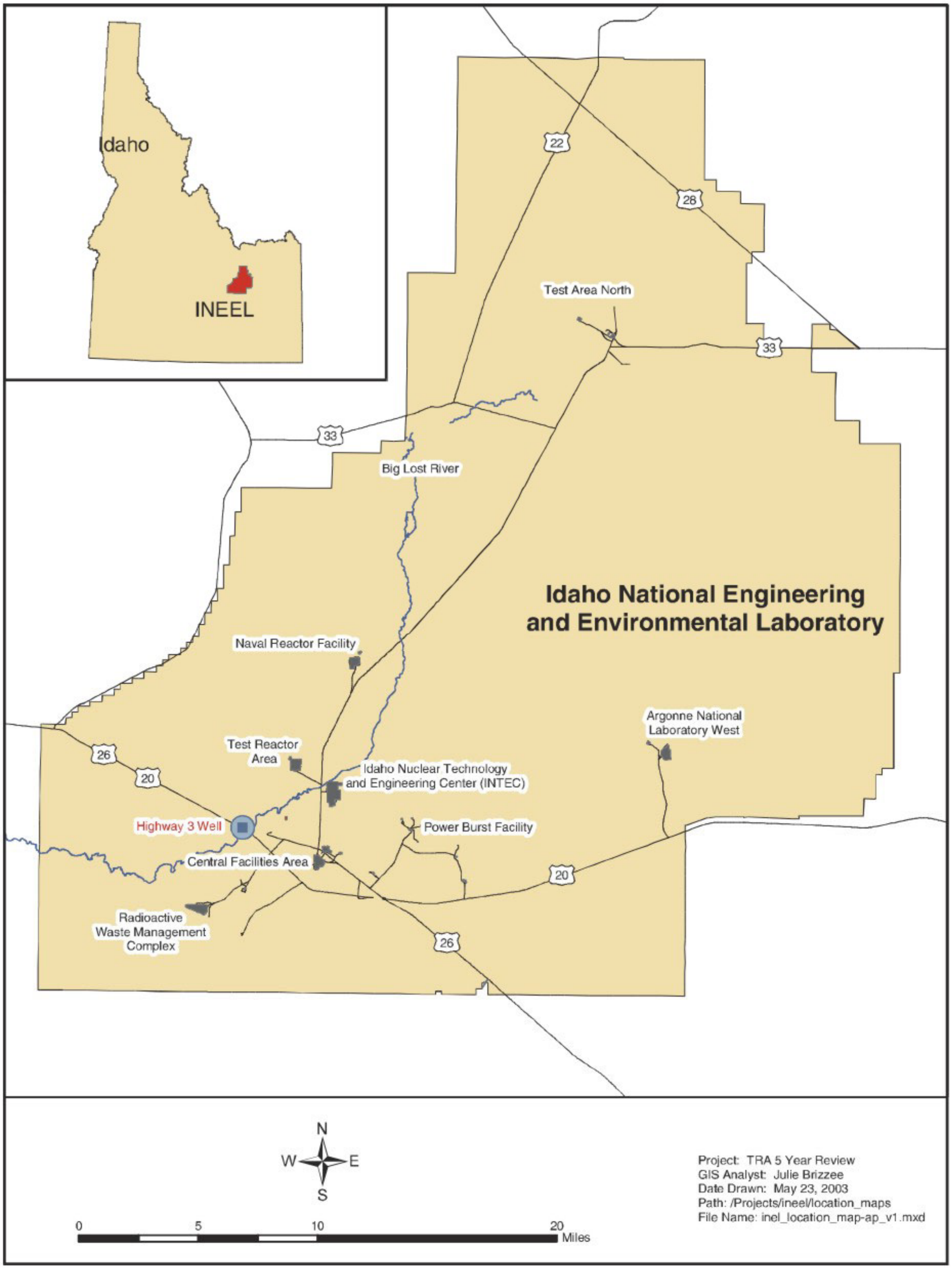

Figure 2. Map of Idaho showing the Idaho National Engineering and Environmental Laboratory and the Test Reactor Area.

channel of the Big Lost River is approximately 1 mi east-southeast of the TRA boundary, and the TRA lies outside of the 100-year floodplain. The Big Lost River flows on an intermittent basis, flowing during years with higher precipitation, mostly associated with snowmelt in mountainous drainages to the west.

The Big Lost River floodplain overlies the eastern Snake River basalt plain (Greeley 1982). This basalt plain was formed by eruption of basalts from low-shield volcanoes and vents. Overlapping flows and intercalated sedimentary deposits produced the complex stratigraphy underlying TRA (see Section 2.2). Geologic features adjacent to TRA include a series of volcanic rift zones, rhyolite domes, and other eruptive features (Anderson 1991). The Arco volcanic rift zone extends southeast across the southwestern part of the INEEL. The axial volcanic rift zone extends southwest across the southeastern part of the INEEL. The Lava Ridge volcanic rift zone extends southeast across the northern part of the INEEL. A series of rhyolite domes occur to the south. The AEC Butte is an eruptive feature immediately northeast of TRA that was the source for an areally extensive, thick basalt unit. The flat-lying character of the basalts and associated sedimentary units indicate that no significant tectonic activity occurred in the immediate vicinity of TRA.

2.2 Stratigraphy/Lithology at the Test Reactor Area

The stratigraphy at TRA consists of a complex stack of basalt flows intercalated with sedimentary deposits above a rhyolitic basement. The upper portion of the basalt-sediment stack is capped with a thick section of surficial alluvial/fluvial deposits. The surficial alluvial deposits are unconsolidated sediments laid down by the fluvial action of the nearby Big Lost River. The alluvial deposits (chiefly sands and gravels) rest atop the undulating surface of a massive basalt flow group; hence, the thickness of the alluvium varies throughout the area. Finer-grained sediments accumulated in local depressions in the basalt surface. In general, thickness of the alluvium ranges from about 32 ft in the northwest section of TRA to about 55 ft in the southern portion with a mean thickness of 49 ft (Anderson 1991).

A thick sequence of basalt flows and sedimentary interbeds lies beneath the surficial alluvium at TRA, extending to depths of 2,000 to 3,000 ft below land surface (bls). The basalt stratigraphy at TRA has been determined by thorough evaluation of cores and cuttings and by correlation of geophysical logs from over 70 wells completed in the eastern SRPA. A total of 17 basalt flow groups were identified, along with at least eight sedimentary interbeds. The basalt flows increase in thickness and decrease in hydraulic conductivity with depth. This decrease can be partially attributed to decreased interflow rubble zones and to secondary mineralization within fractures and other porous regions of the flows. Two interbeds within the vadose zone are of hydrologic significance. The first is located above the DE-4 basalt flow group at an approximate depth of 140 to 200 ft. The thickness of this sedimentary interbed measures approximately 60 ft, and it has been encountered in 14 of 17 wells drilled in the area. A second significant sedimentary interbed is encountered in Well USGS-65 at about 500 ft bls (INEEL 2003).

2.3 Perched Water at the Test Reactor Area

Shallow and deep perched-water bodies have formed in the vadose zone at TRA in response to infiltration of wastewater disposed of to unlined ponds. These perched-water bodies developed as the rate of infiltrating water exceeded the capacity of a low-permeability layer to transmit water. Barriers to the vertical migration of water induced a local saturated condition and lateral spreading of the perched water along the top of the low-permeability layer. The size or “footprint” of the perched-water body expanded until sufficient area was wetted to transmit the flux of infiltrating water. Alternatively, water might have “spilled” over the edge of a perching layer that is not laterally extensive. Thus, widespread layers with very low permeability formed larger perched-water bodies. The footprint and depth of the perched-water body increased or decreased as the rate of infiltration increased or decreased. Figure 3 is a conceptual drawing illustrating the development of perched water at TRA.

Discharge of water to the TRA ponds (see pond locations on Figure 1) is recognized to have contributed to the formation of the perched-water zones. Historically, the CWP, in service since 1982, has been the largest source of water to the perched-water zones. The average discharge rate to the CWP between early 1982 and late 1991 was 460 gpm. Since late 1991, discharges to the CWP have averaged 380 gpm. Prior to implementation of the CWP, the Warm Waste Pond (WWP), first constructed in 1952, had been the principle source of infiltration to the perched-water zones. The WWP continued to contribute a significant amount of recharge to the perched-water zone until it was taken out of service in 1993. Water used for landscape irrigation within TRA also has contributed to the perched water. In the past, other surface sources of water (including the former WWP, Sewage Pond, and the Chemical Waste Pond) contributed a much smaller amount to the subsurface. A history of liquid effluent discharge to ponds for the period of 1982–2003 is shown in Figure 4 (DOE-ID 2003).

Water-level trends in several perched-water wells correspond directly to the disposal rates to the CWP. The thickness and size of the two perched-water zones have changed over time, depending on the amount of water discharged to the ponds. The relationship between pond discharge and the footprint of the perched-water bodies has been tracked and described in numerous reports (e.g., EG&G Idaho 1989; EG&G Idaho 1991a; Dames and Moore 1992a).

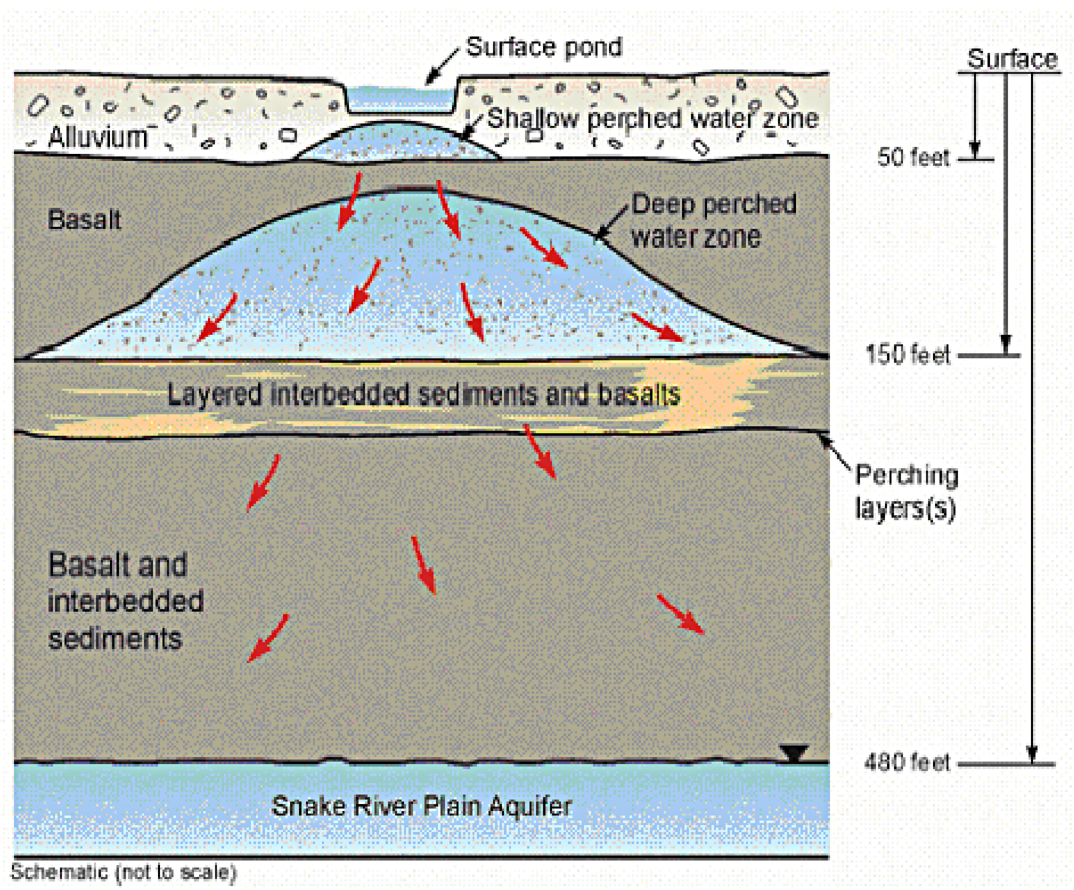

Figure 3. Conceptual diagram demonstrating perched-water formation.

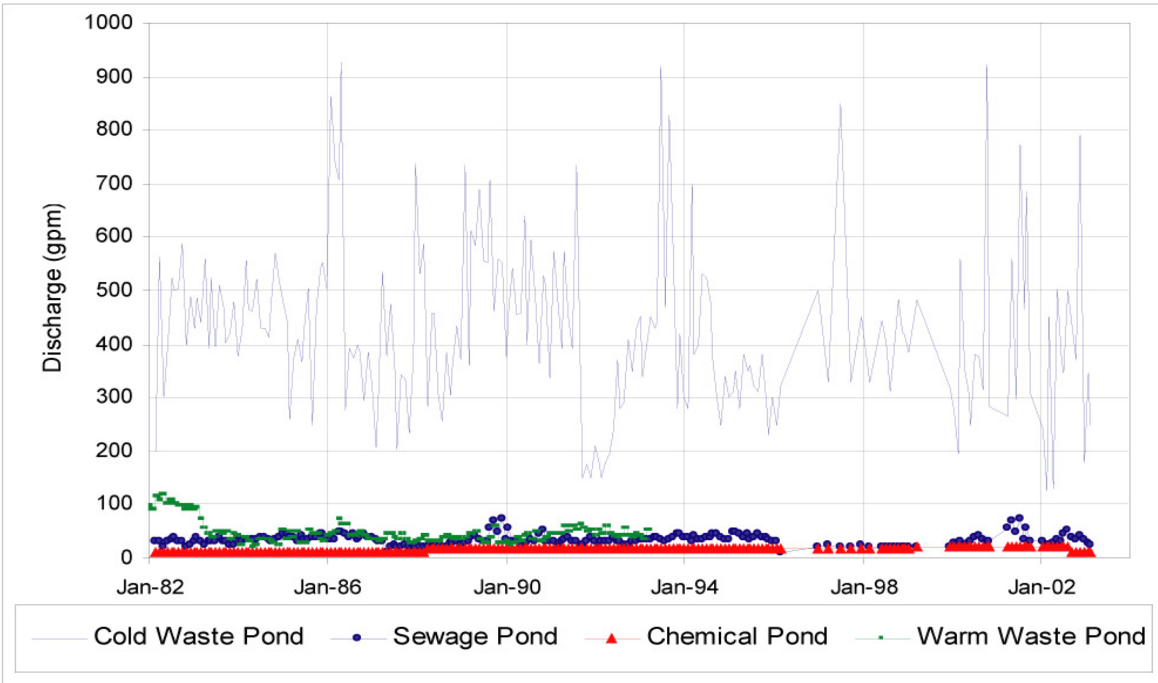

Figure 4. Graph of historic discharge to Test Reactor Area waste ponds.

A shallow perched-water zone formed on a layer of fine-grained sediments at the alluvial-basalt contact—about 50 ft bls. This zone is monitored routinely in 11 shallow wells (CWP-01 through CWP-09, TRA-A13, and TRA-A77) (see Figure 1). Because of variations in discharge to the pond(s), most of the shallow perched-water wells have shown episodic wetting and drying since 1990 (CWP-01 and CWP-09 have been continually wet over the period of record). When the WWP was removed from service in 1993 and replaced by a lined evaporation pond, the volume of infiltrating water was decreased slightly, as noted in Figure 4. The result of this decrease was small and made only a slight difference in the shallow perched-water zone's footprint.

The deep perched-water zone formed within a section between 140 and 200 ft bls consisting of low-permeability sediments, dense basalts, and basalt with sediment-filled fractures. Because the deep-perched zone has a larger footprint than the shallow perched zone, this layer's composite permeability is considered to be less than that of the perching layer for the shallow perched-water zone. Alternatively, the deep perching horizon may be of larger areal extent than that of the shallow horizon with vertical flow through the shallow horizon increasing at the edge of the perching layer perched-water zone. The deep perched-water zone is monitored by 17 wells that are sampled routinely for contaminants of concern.

A contour map was constructed showing the configuration of the deep perched-water zone in 1991. This map (Figure 5) was developed for the *Record of Decision Test Reactor Area Perched Water System Operable Unit 2-12, Idaho National Engineering and Environmental Laboratory* (DOE-ID 1992). The deep perched-water zone ranged in elevation from less than 4,750 ft above mean sea level (amsl) to greater than 4,860 ft amsl. The zone was elongated in a northwest to southeast direction and was

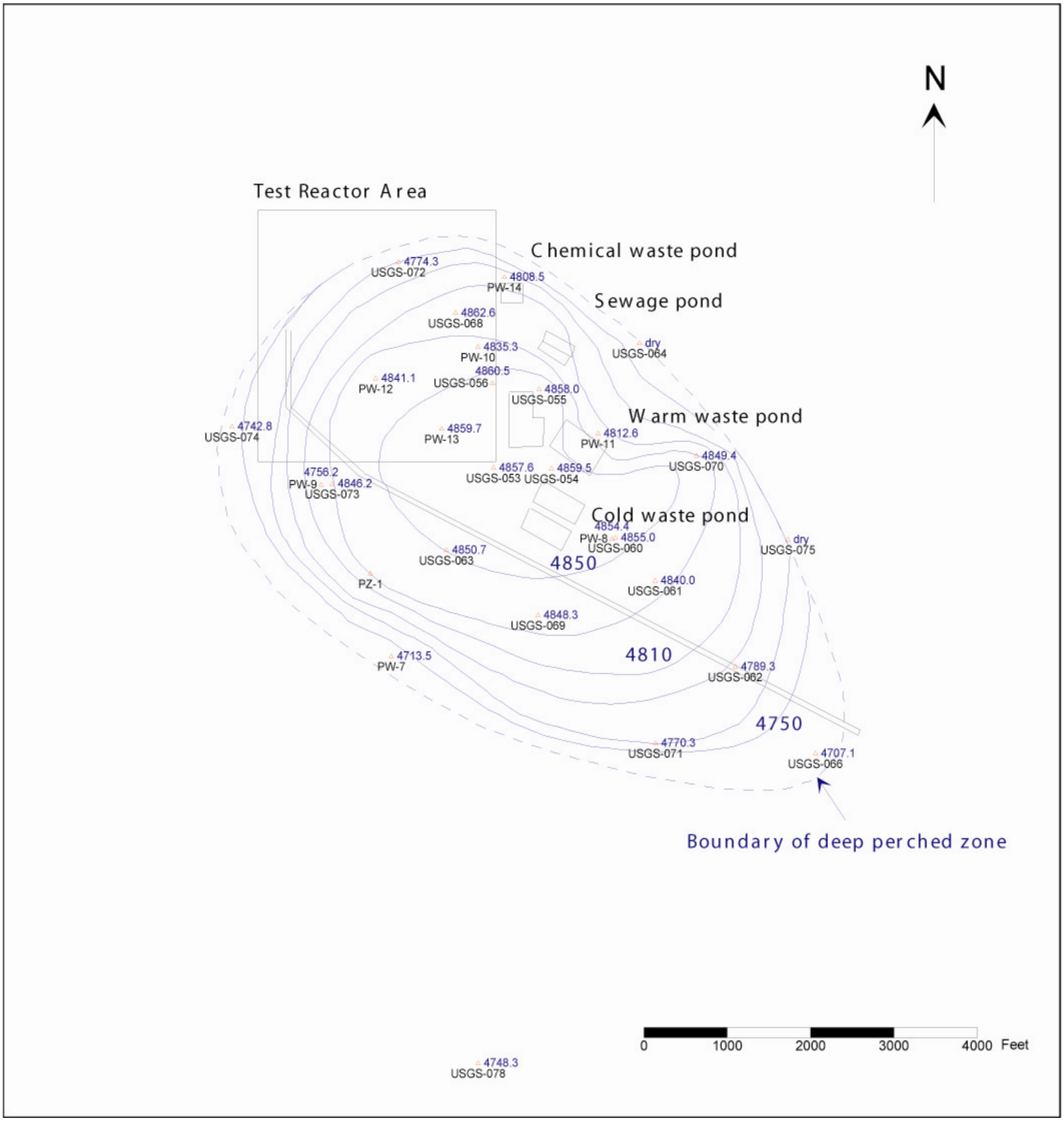

Figure 5. Configuration of the perched water at Test Reactor Area based upon 1991 water-level elevations.

characterized by a broad, flat top with steeply sloping flanks. The highest water levels were centered beneath the CWP and WWP. Figure 6 depicts the configuration of the deep perched-water zone 12 years later with contours on the surface of the deep-perched zone for November 2003. The deep perched-water zone was narrower and the elevations ranged from less than 4,730 ft amsl to greater than 4,850 ft amsl. Water levels had declined from the 1991 measurements and the highest water levels were centered beneath the CWP. Water-level declines are attributed to a slight decrease in discharge to the CWP between 1991 and 2003 and to discontinuation of disposal to the WWP in 1993.

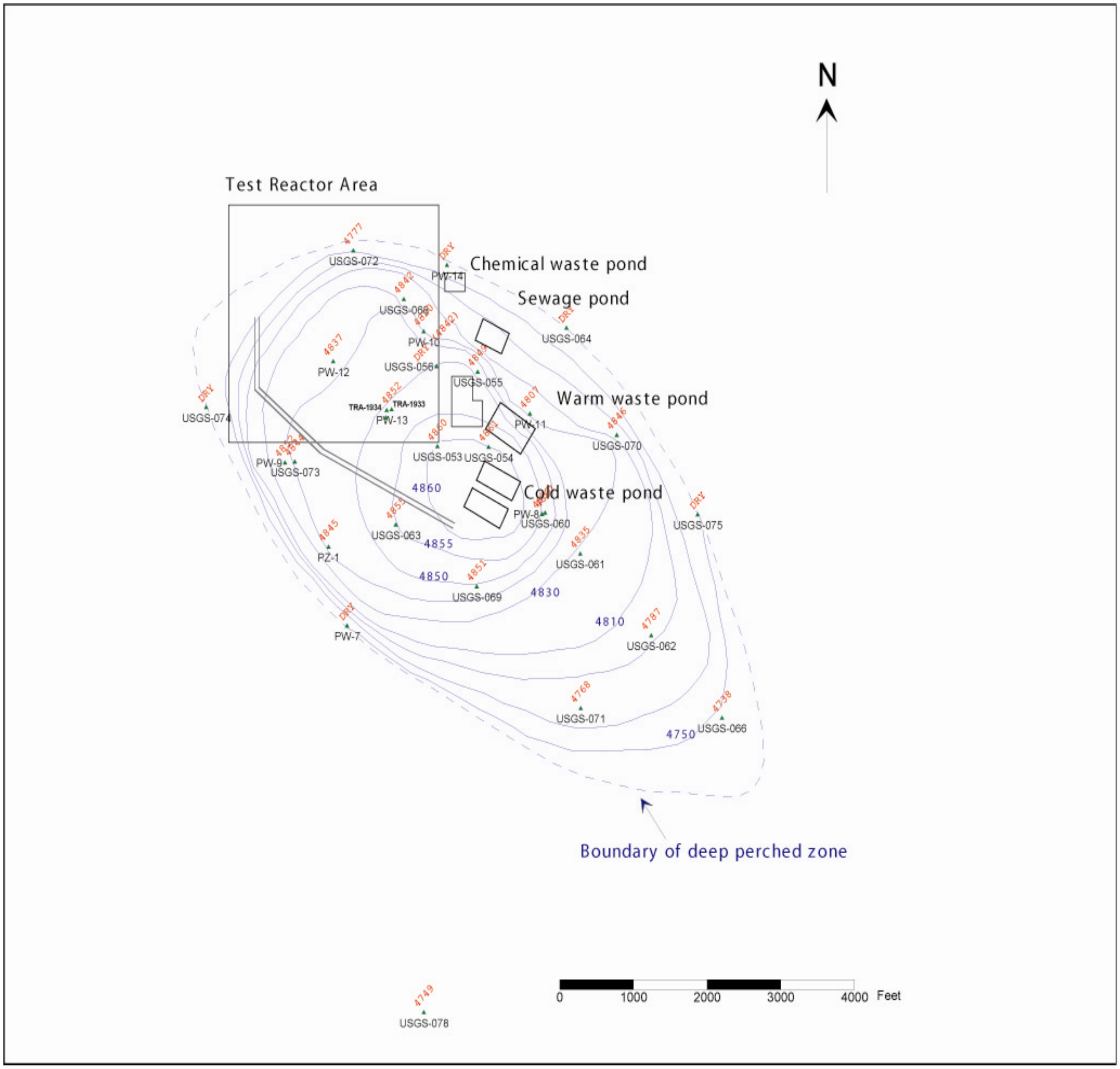

Figure 6. Configuration of the perched-water zone at Test Reactor Area, modified from November 2003 data.

2.4 Snake River Plain Aquifer at the Test Reactor Area

The SRPA is defined as the series of water-bearing basalt flows and the interlayered pyroclastic and sedimentary materials that underlie the eastern Snake River Plain east of Bliss, Idaho (EG&G Idaho 1989). The SRPA is approximately 200 mi long, 40 to 60 mi wide, and covers an area of 9,600 mi^2 (EG&G Idaho 1989). The aquifer is very permeable because of the presence of fractures, fissures, and rubble zones at contacts between individual basalt flows. On October 7, 1991, the EPA designated the SRPA as a sole-source aquifer under the "Safe Drinking Water Act" (42 USC § 300f to 300j-26). At TRA, the top of the SRPA occurs at a depth of approximately 480 ft bls.

Generally, groundwater in the SRPA flows to the southwest under the ambient hydraulic gradient (Figure 7). Figure 8 depicts the aquifer water table at TRA in October 2002. The inherent heterogeneity of the fractured basalt aquifer makes it very difficult to contour the water table, and local flow directions may vary significantly. Figure 8 also shows the inferred direction of groundwater flow at TRA. The direction of flow is inferred, because the aquifer's highly heterogeneous nature creates anisotropy that can result in flow paths not perpendicular to the water-level contours. Fluctuating water levels caused by recharge and pumping further complicate determination of the local groundwater flow directions. Groundwater flow at TRA is generally to the southwest (Figure 8), but the local direction of flow and gradient of the water table varies in both time and space.

Infiltrating groundwater from the deep perched-water zone moves downward over a large diffuse area, probably under varying levels of saturation, until it intersects the upper surface of the SRPA. The perched-water recharge to the aquifer appears insufficient to cause local mounding, as this has not been observed in the TRA aquifer wells. Recharge is rapidly diluted in the SRPA because of the relatively fast (4.3 ft/day) rate of flow in the aquifer (EG&G Idaho 1991a). However, a thin, laterally extensive sedimentary layer located beneath the water table at a depth of 488 ft bls may restrict dilution locally beneath TRA. Wells USGS-065 and TRA-06A—although only approximately 100 ft apart—have different completion depths and, because of the sedimentary interbed, tap two different zones in the aquifer (see Figure 9). Well USGS-065 has an open-hole interval from 456–498 ft bls. Well TRA-06A is screened from 528–558 ft bls. As shown in Figure 9, the open interval of USGS-065 terminates in the interbed, tapping about 8 ft of the aquifer above the interbed. Conversely, the screened interval of TRA-06A is beneath the depth of this interbed with about 40 ft of filter pack exposed to the aquifer. It should be noted that the interbed was not noted during the drilling of TRA-06A. However, a rubble/cinder zone was encountered, possibly indicating an interflow zone that might contain a thin interbed. It may be possible that dilution of contaminants with aquifer water near USGS-65 may be restricted by sedimentary interbed. The presence of this sedimentary interbed, just beneath the water table, could explain the higher groundwater concentrations measured in wells completed above the interbed (DOE-ID 2003).

It is also possible that USGS-065 might have served as a vertical conduit for flow from the deep perched-water zone. In USGS-065, well casing (shown in Figure 9 as thick lines) extends to a depth of 456 ft bls with a grout seal extending from 456 to 355 ft bls. A string of outer casing extends from ground surface to 326.5 ft bls. A second grout seal extends from ground surface to 15 ft. The well completion is open hole. Under saturated or "perched-water" conditions, the open annulus behind the outer casing may provide a pathway for rapid vertical migration of water to the top of the seal at 355 ft. Sloughing and caving of the formation against the well casing would reduce this migration, but its presence is not documented. The perched water in the area of the wells has receded and PW-07 has been dry since October 1994. Unless the deep perched-water zone expands back into this area, future rapid vertical transport at this location will not threaten the aquifer's water quality (DOE-ID 2003).

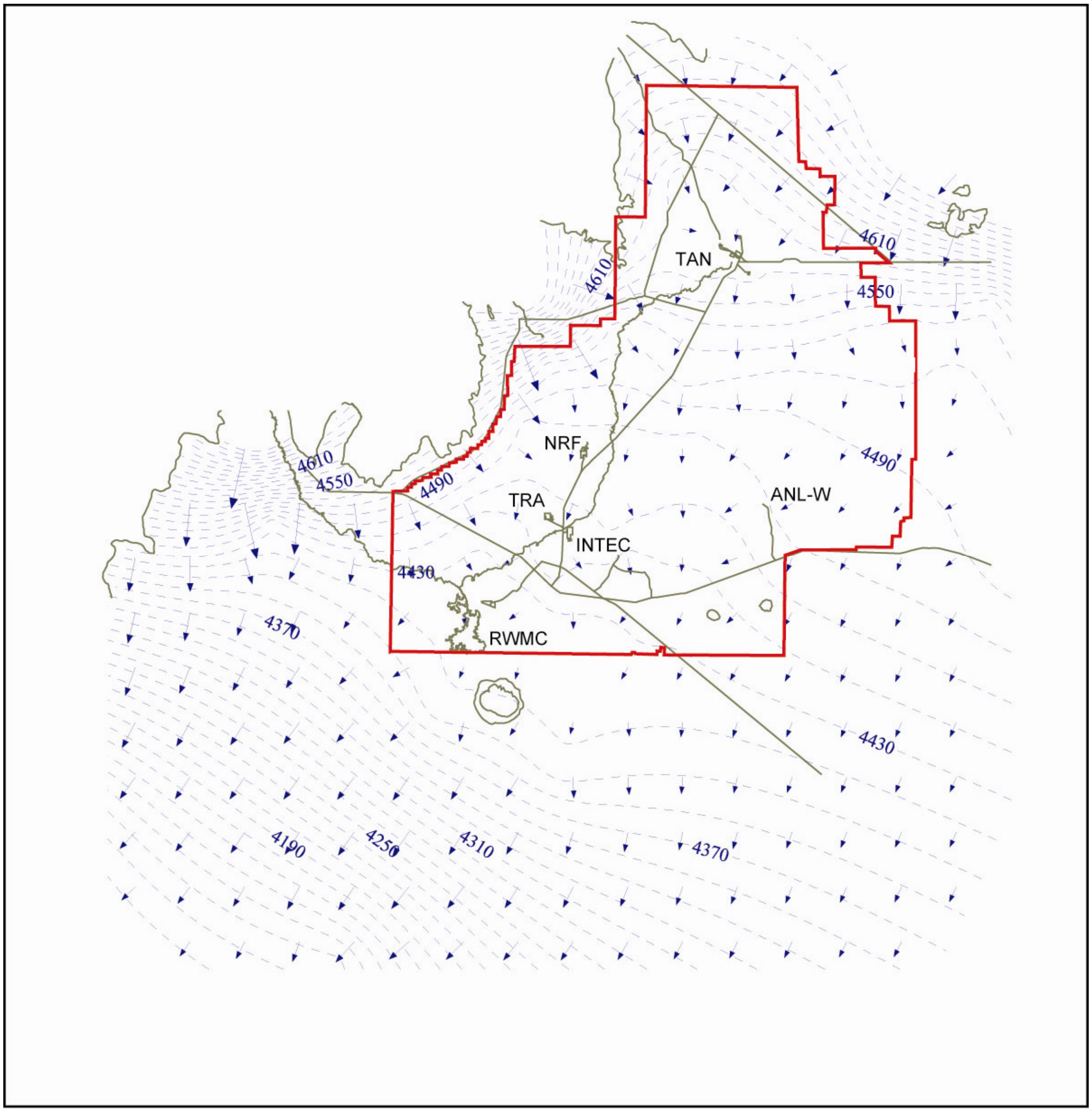

Figure 7. June 2004 water-table elevation contour map.

NOTE: *Water-table measurements are in feet above mean sea level for the Snake River Plain Aquifer in the vicinity of the INEEL with hydraulic gradient vectors (shown proportional to gradient magnitude).*

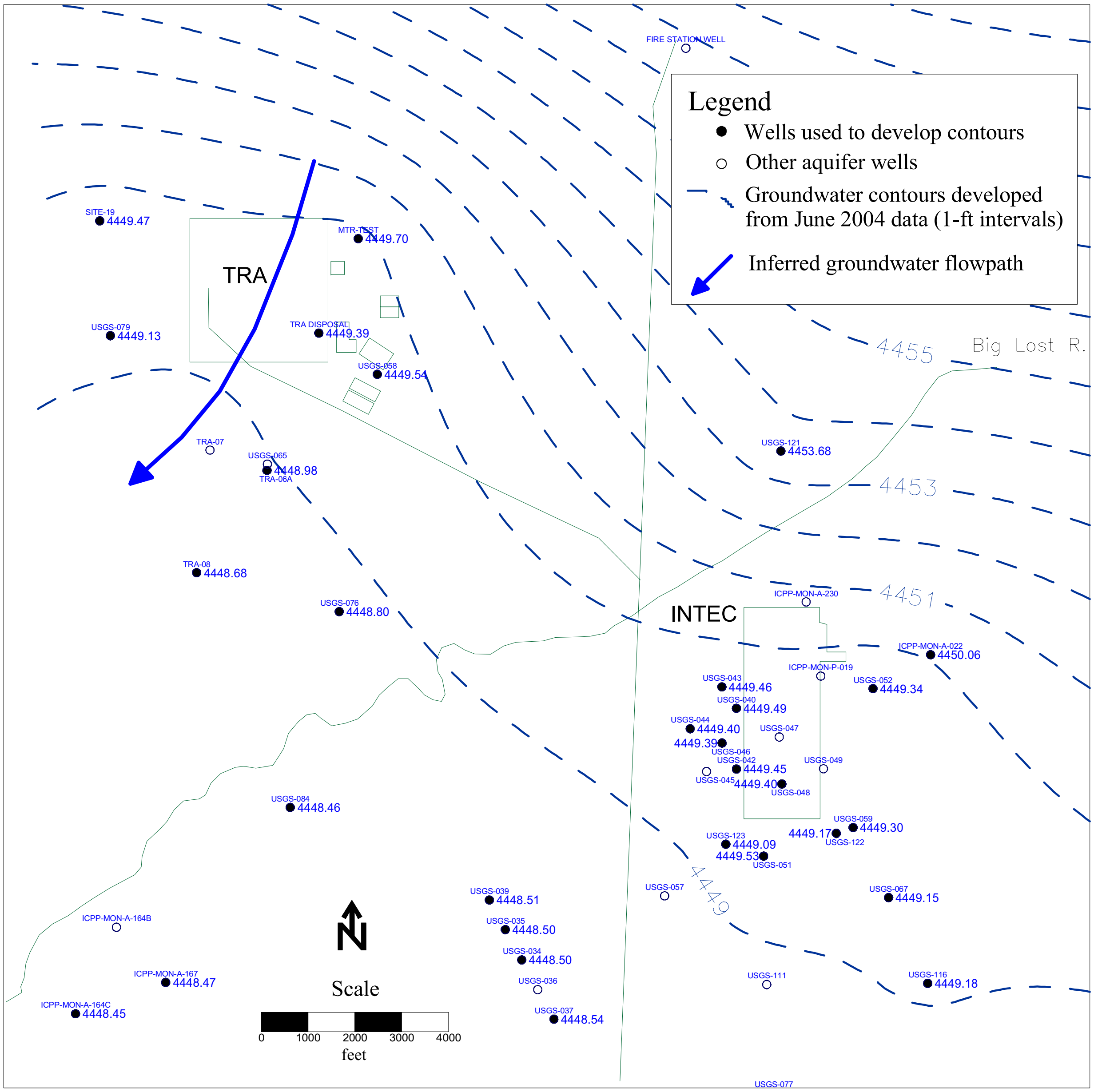

Figure 8. Snake River Plain Aquifer water-table configuration for June 2004.

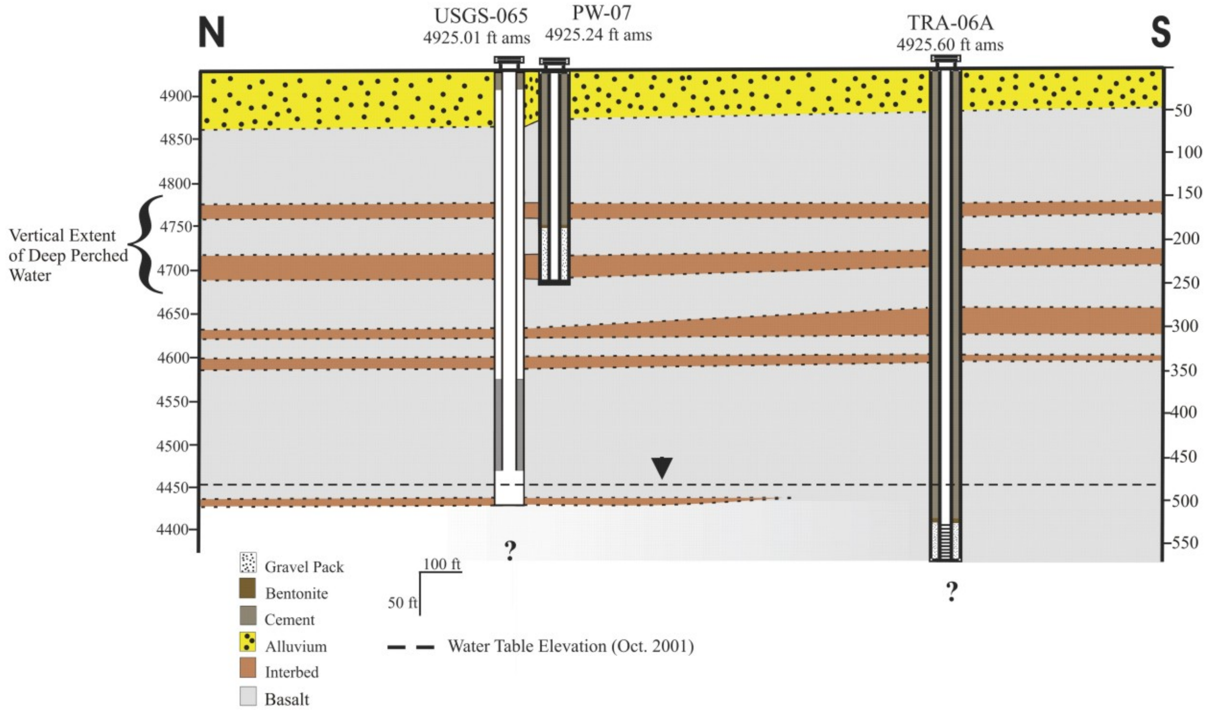

Figure 9. Generalized cross-section showing the stratigraphy at Wells USGS-065, TRA-06A, and PW-07.

3. WELL PW-13 DIESEL INVESTIGATION

3.1 Introduction

The First Five-Year Review Report (DOE-ID 2003) identified the recurrence of free-phase diesel fuel in the PW-13 TRA perched-water well as an issue. As a best management practice, the diesel contamination was further investigated to determine if the associated risk was greater than previously believed. This section documents that investigation. A short history of the diesel contamination at Well PW-13 is provided in Section 3.2. The drilling and installation of two new perched-water wells, TRA-1933 and TRA-1934, are detailed in Section 3.3. Analytical results from groundwater sampling in and around Well PW-13 are presented in Section 3.4. The extent of the diesel contamination is discussed in Section 3.5. Potential mechanisms for the recurrence of free-phase diesel in Well PW-13 are described in Section 3.6. The findings of this investigation are summarized in Section 3.7 and recommended actions are provided in Section 3.8.

3.2 Diesel Contamination at Well PW-13

Well PW-13 is located approximately 50 ft southeast of the Engineering Test Reactor (ETR) on the south end of Pike Street within TRA (see Figure 10). This well was installed in 1990 to monitor the deep perched-water zone. A layer of free-phase diesel fuel was discovered at the water surface of PW-13 during initial coring and was removed prior to well completion. The contamination at PW-13 was first investigated in 1994 as a Track 2 investigation (Sherwood et al. 1994). The PW-13 Track 2 investigation pointed to a diesel transfer line (TRA-57) as the source of contamination and a No Further Action determination was made. A subsequent Track 1 investigation of the TRA-57 transfer line recommended continued monitoring of PW-13 (INEEL 2002).

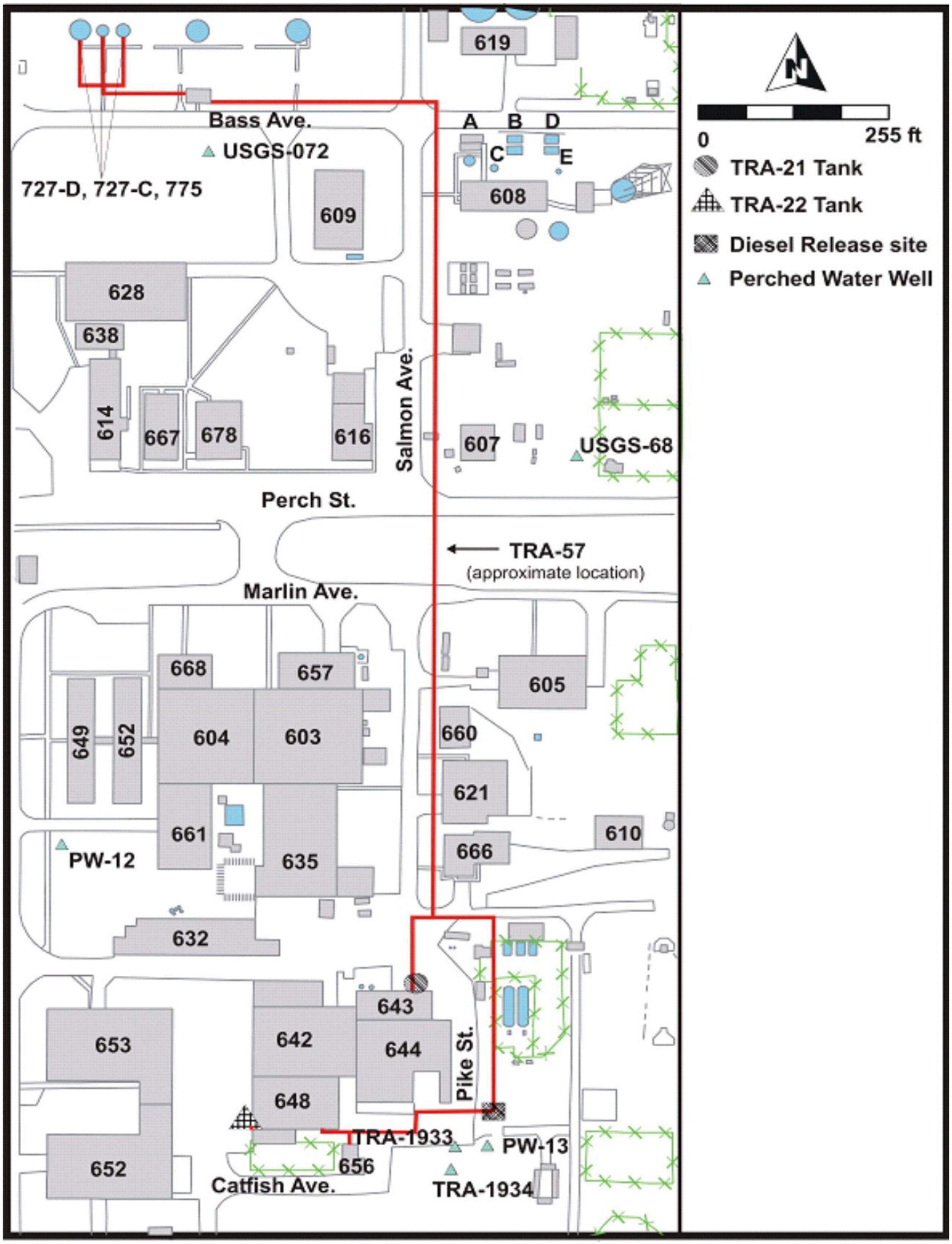

Figure 10. Map of the Test Reactor Area with well locations and the approximate location of the TRA-57 fuel transfer line and the diesel release.

Free-phase diesel fuel has been observed in PW-13 on several occasions since 1999. In each case, the floating diesel layer disappeared from the well without remediation. This section (Section 3.2) of the report details the installation of PW-13 and initial discovery of diesel (Section 3.2.1), history of the diesel contamination at PW-13 (Section 3.2.2), and the probable source as identified in the 1994 Track 2 investigation (Section 3.2.3).

3.2.1 Well PW-13 Construction and Completion

Information concerning the drilling and installation of Well PW-13 was compiled from the project logbooks, ERP-126-90 and ERP-60-90, unless otherwise noted.

Well PW-13 was drilled and cored in August–September of 1990. Surface casing was set to a depth of 42 ft bls with a tricone bit. The surface casing extends through the alluvium and penetrates approximately 3 ft into the underlying basalt. After the surface casing was grouted in place, the well was cored to total depth using an HQ barrel. Coring was halted at the end of the shift on September 5, 1990, at a depth of 145.2 ft bls. A diesel odor was noted on the first core pulled when operations resumed on September 6, 1990; operations were halted at this depth (148.5 ft bls). The onsite geologist did not note any diesel odor or staining on any of the core at the time of coring. The water level was recorded at 75.5 ft bls. The core hole was bailed intermittently over the next 2 months until recovery of free product ceased. A full history of the contamination at PW-13 is located in Section 3.2.2.

The core hole was grouted from 148.5 to 95 ft bls on November 8, 1990. The hole was then over reamed with a 9-7/8-in. drill bit from 42.0 to 97.0 ft bls on November 9, 1990. A bentonite seal was installed from 97.0 to 88.5 ft bls. Installation of the well began on November 14, 1990. A 0.020-in. slot, 4-in. stainless-steel well screen was installed from 87.5 to 57.5 ft bls; 4-in. wire-wrapped, stainless-steel well casing was installed from 57.5 ft bls to 2.5 ft above land surface; and a filter pack of 10 × 20 silica sand from 88.5 to 51.0 ft bls. A bentonite seal extends from 51.0 ft bls to the surface casing that was grouted in place at 42.0 ft bls. The well was developed on January 9, 1991. During development, 15 gal of water was bailed from the well, but no diesel contamination was noted. Figure 11 shows the well completion diagram and lithology for PW-13.

As part of the recent investigation, a review of the PW-13 core in December 2003 at the United States Geological Survey (USGS) Core Library also did not reveal any diesel odor or staining.

3.2.2 History of Diesel Contamination in Well PW-13

As stated above, diesel odor was noted during the coring of Well PW-13 on September 6, 1990. The core rods were removed, and samples of the floating product were collected for analysis. The initial samples indicated that the product was diesel fuel (EG&G Idaho 1990). Sampled free-product density was measured at 0.84 g/mL, which is near the diesel density of 0.827 g/mL. The increased density likely reflects the decay of gasoline-range aliphatic and cycloalkane hydrocarbons. A video log of the core hole completed after reaching total depth showed an approximately 8.5-ft-thick layer of free-phase diesel floating above the diesel-water interface at 75.5 ft bls (4,847.8 ft above mean sea level). The video log also showed what may have been diesel fuel entering the core hole from a fractured basalt zone at 47 ft bls, which is ~7 ft below the basalt-alluvium contact.[c] Over the next 6 weeks, the thickness of free-phase diesel in the core hole was measured. The free-phase diesel also was removed by bailing. Approximately 20 gal of diesel was removed between September 7 and November 9, 1990. The volume

c. INEEL Logbook ERP-126-90.